Hurricane Prediction Across Timescales at NOAA/GFDL

Presented by Gabriel A. Vecchi

NOAA/GFDL

Hurricane Prediction Across Timescales

DAYS (GFDL Hurricane Model)

MONTHS (HiRAM 25km Seasonal Forecasts)

SEASONS (HyHuFS Hybrid Forecast System)

YEARS (Decadal HyHuFS)

DECADES (Response to radiative forcing)

Sources of & Limitations on climate predictability

years to decade

hours to a month

Climatology

(what happens typically, including randomness)

need good observations, models

Evolution of initial conditions

(*e.g.*, weather or El Niño forecast)

need good observations, models, initialization schemes

Many decades to centuries

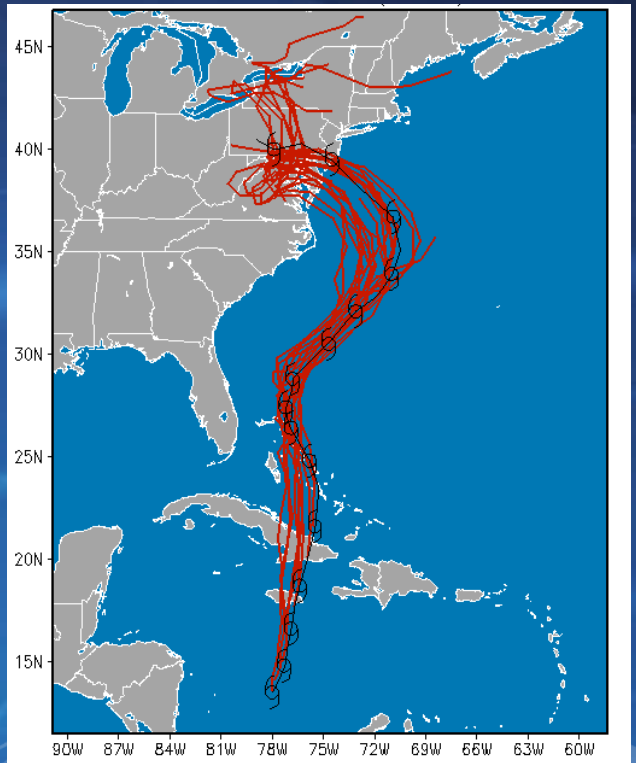
Climatology

Climate response to forcing

(*e.g.*, CO_2, aerosols, sun, volcanoes)

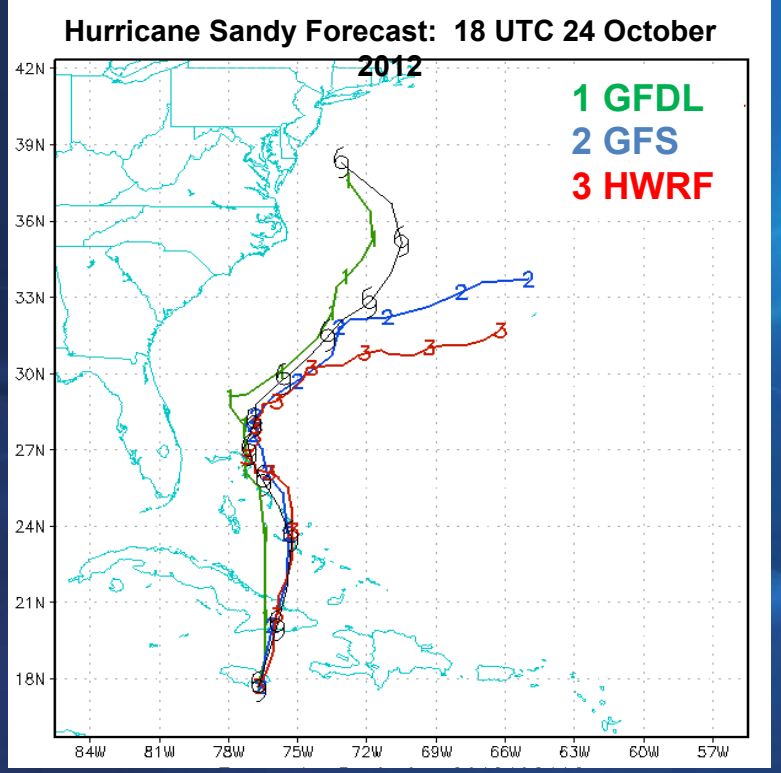
need good models and estimates of forcing

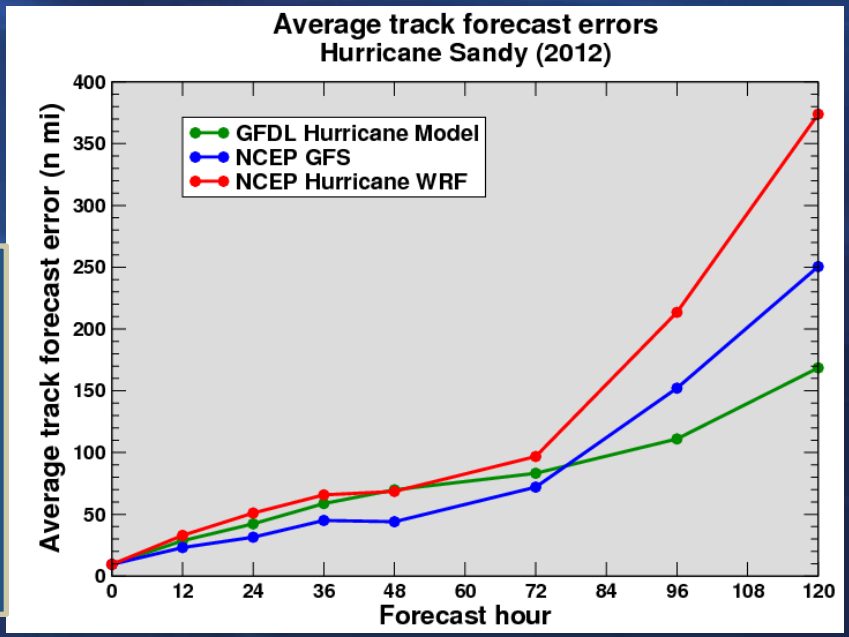
DAYS: GFDL Hurricane Model



All GFDL track forecasts for Hurricane Sandy, beginning 12 UTC 23 October 2012

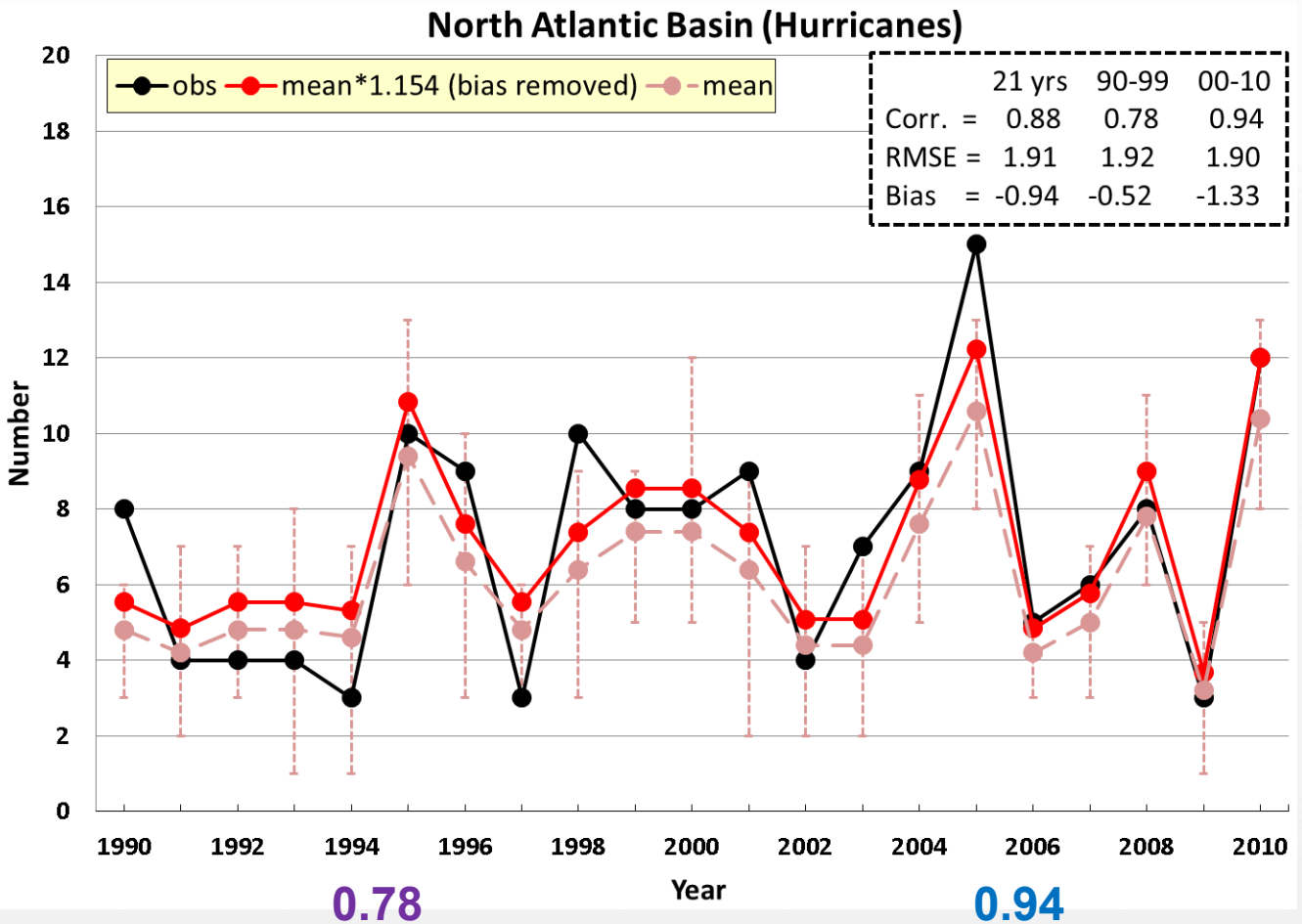
Track Forecast Performance of GFDL Hurricane Model for Hurricane Sandy





- First operational U.S. forecast model to correctly predict Sandy's "left turn"
- GFDL model significantly more skillful than the other two NWS forecast models (GFS, HWRF) at 4- and 5-day lead time.

MONTHS: 25km HiRAM Seasonal hurricane predictions – initialized July 1 1990-2010

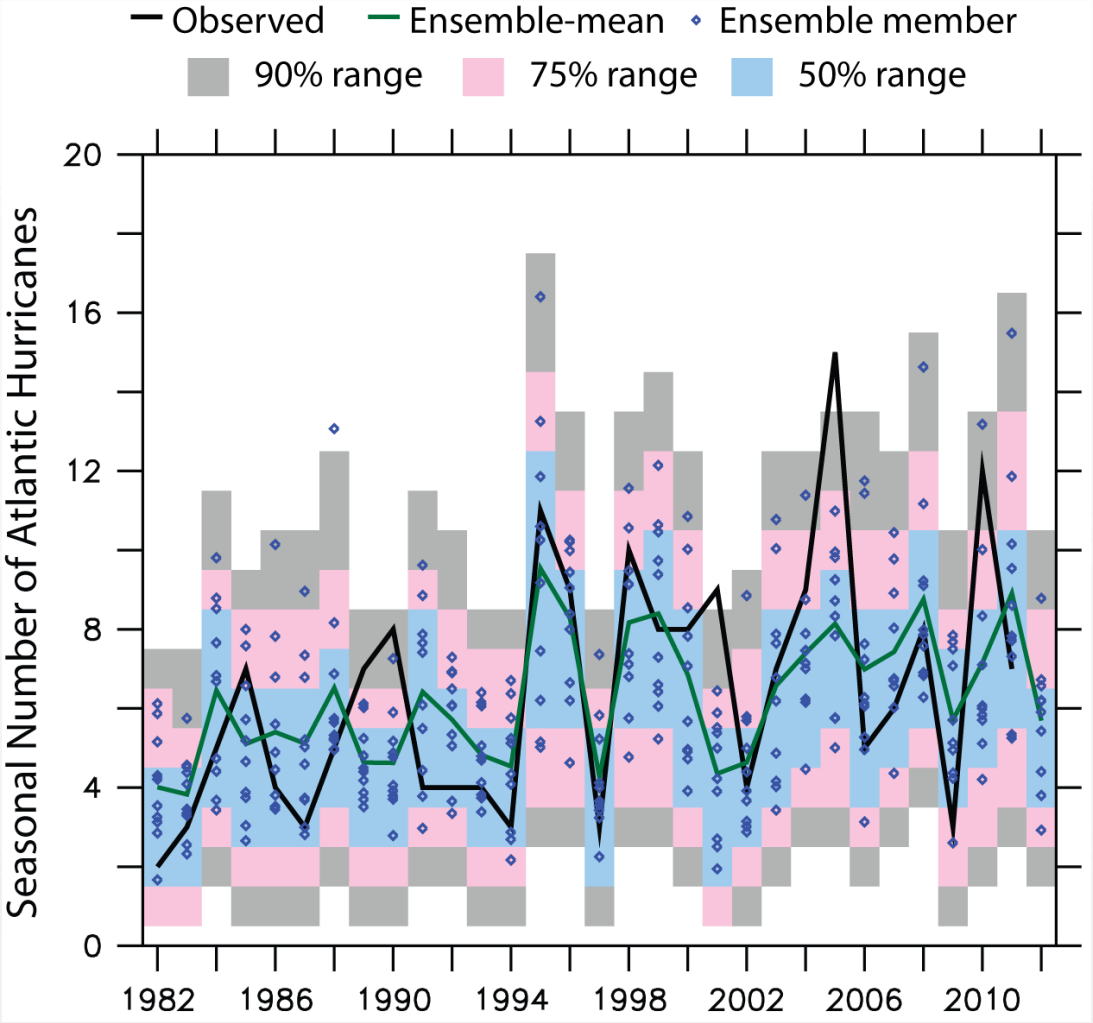


Resolution: 25 km, 32 levels

- 5-members initialized on July 1 with NCEP analysis
- SST anomaly is held constant during the 5-month predictions
- Climatology O3 & greenhouse gases are used

Zhao et al. 2010
Chen and Lin 2011
Chen *et al*., 2012

SEASONS: HyHuFS long-lead forecasts system. Skill from as early as October of year before



Initialized January: r=0.66

May & onward forecasts fed to NOAA Seasonal Outlook Team

http://gfdl.noaa.gov/HyHuFS

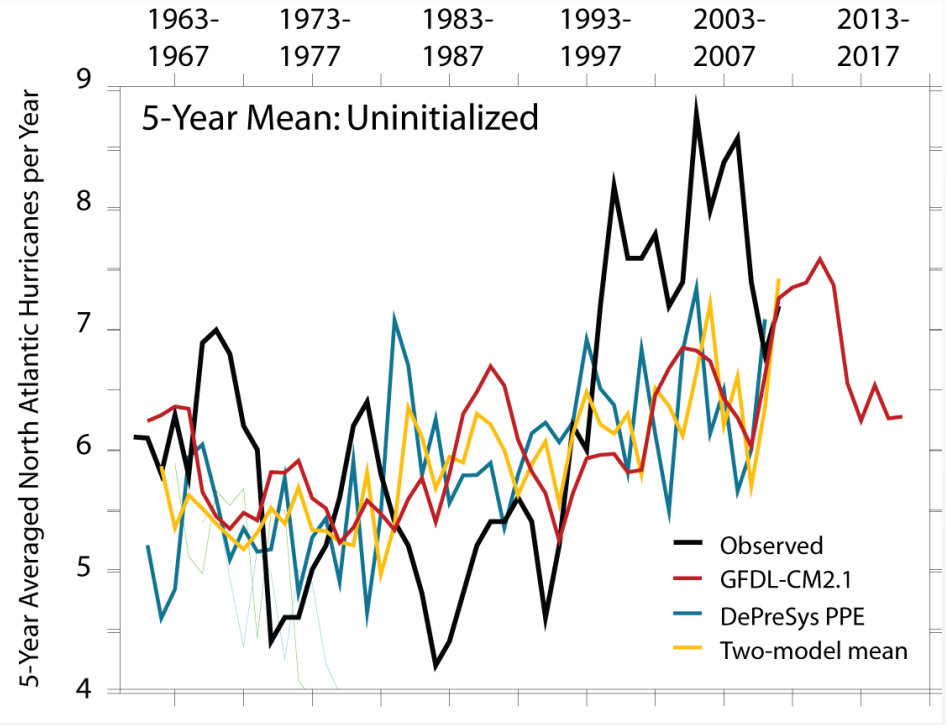
Prediction for 2013: active

Vecchi et al. (2011), Villarini and Vecchi (2013)

YEARS: Initialization improves 5-year predictions

Hybrid system: statistical hurricanes, dynamical decadal climate forecasts

FORCED



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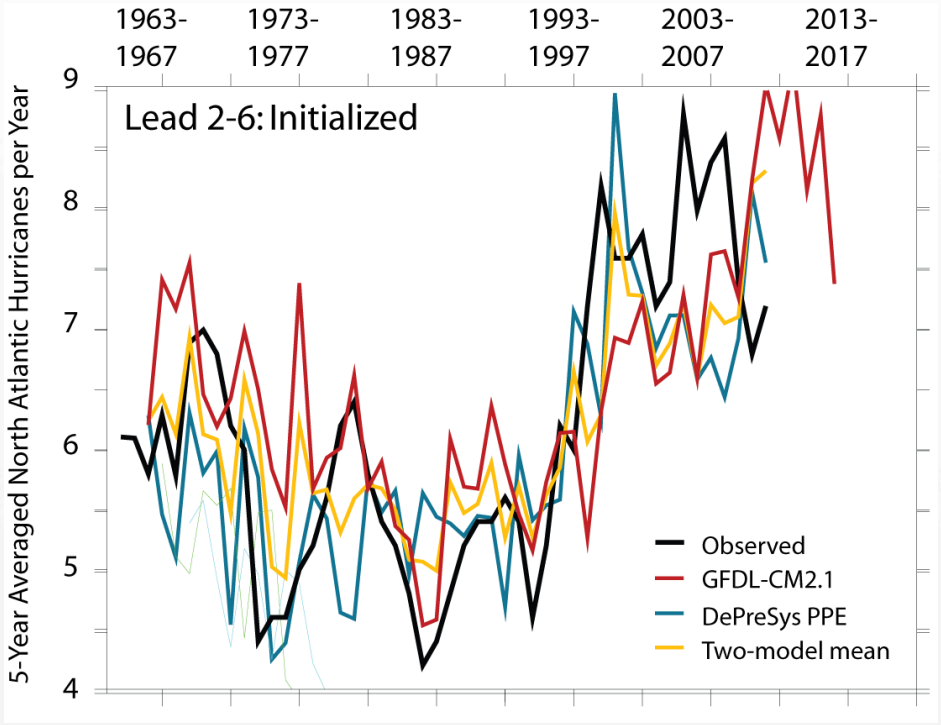

- Retrospective predictions encouraging.
- However, small sample size limits confidence
- Skill arises more from recognizing 1994-1995 shift than actually predicting it.

EXPERIMENTAL: NOT OFFICIAL FORECAST

Vecchi et al. (2013.a, J. Clim. in press)

YEARS: Initialization improves 5-year predictions

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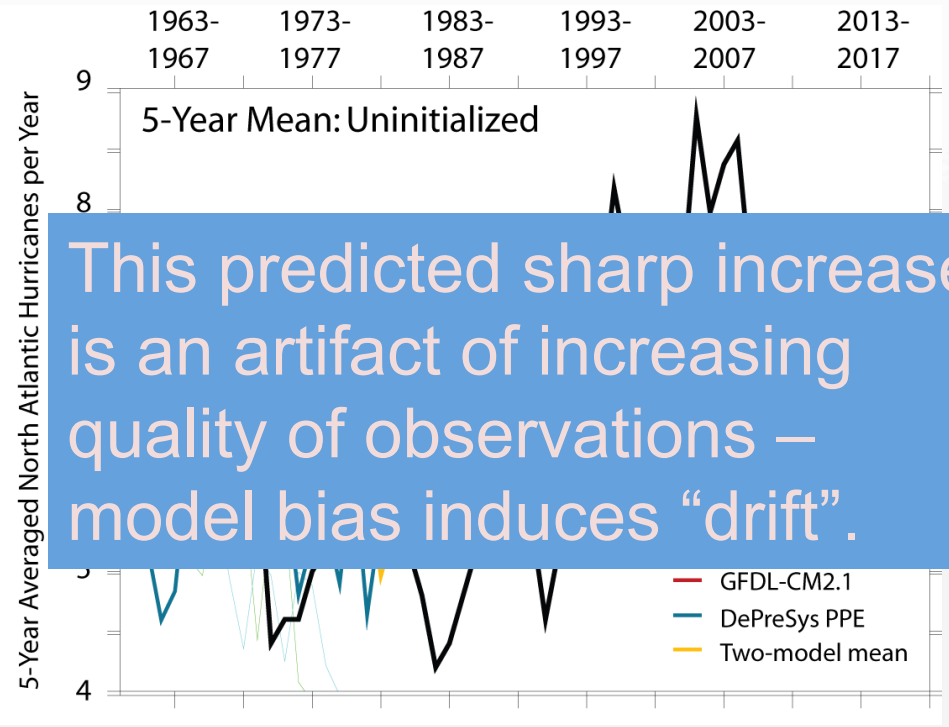

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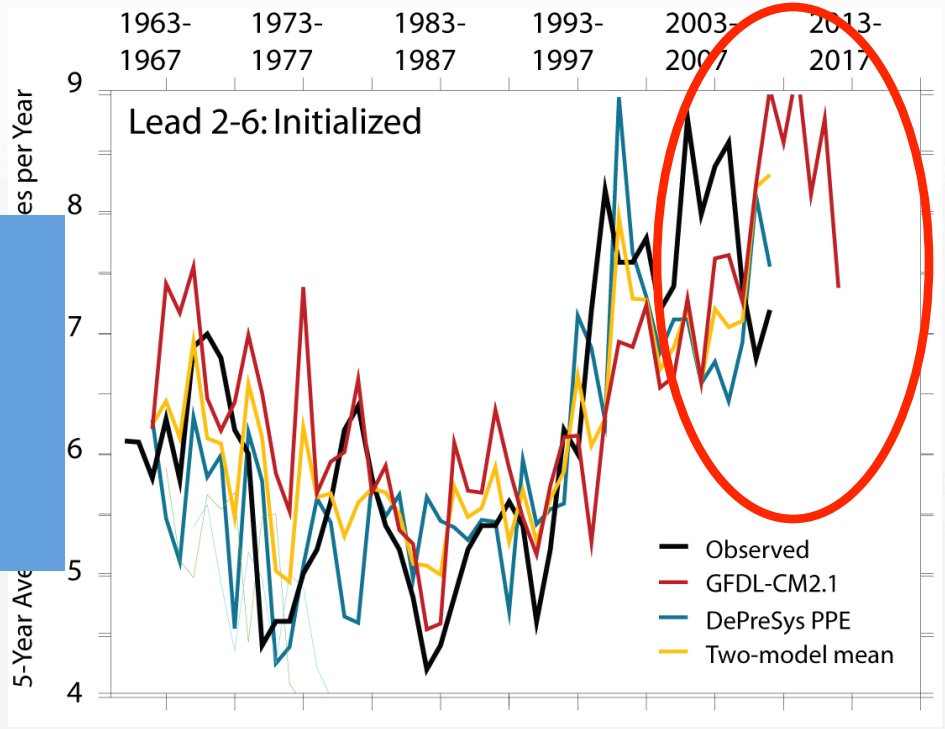

This predicted sharp increase is an artifact of increasing quality of observations – model bias induces "drift".

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EXPERIMENTAL: NOT OFFICIAL FORECAST

Vecchi et al. (2013.a, J. Clim. in press)

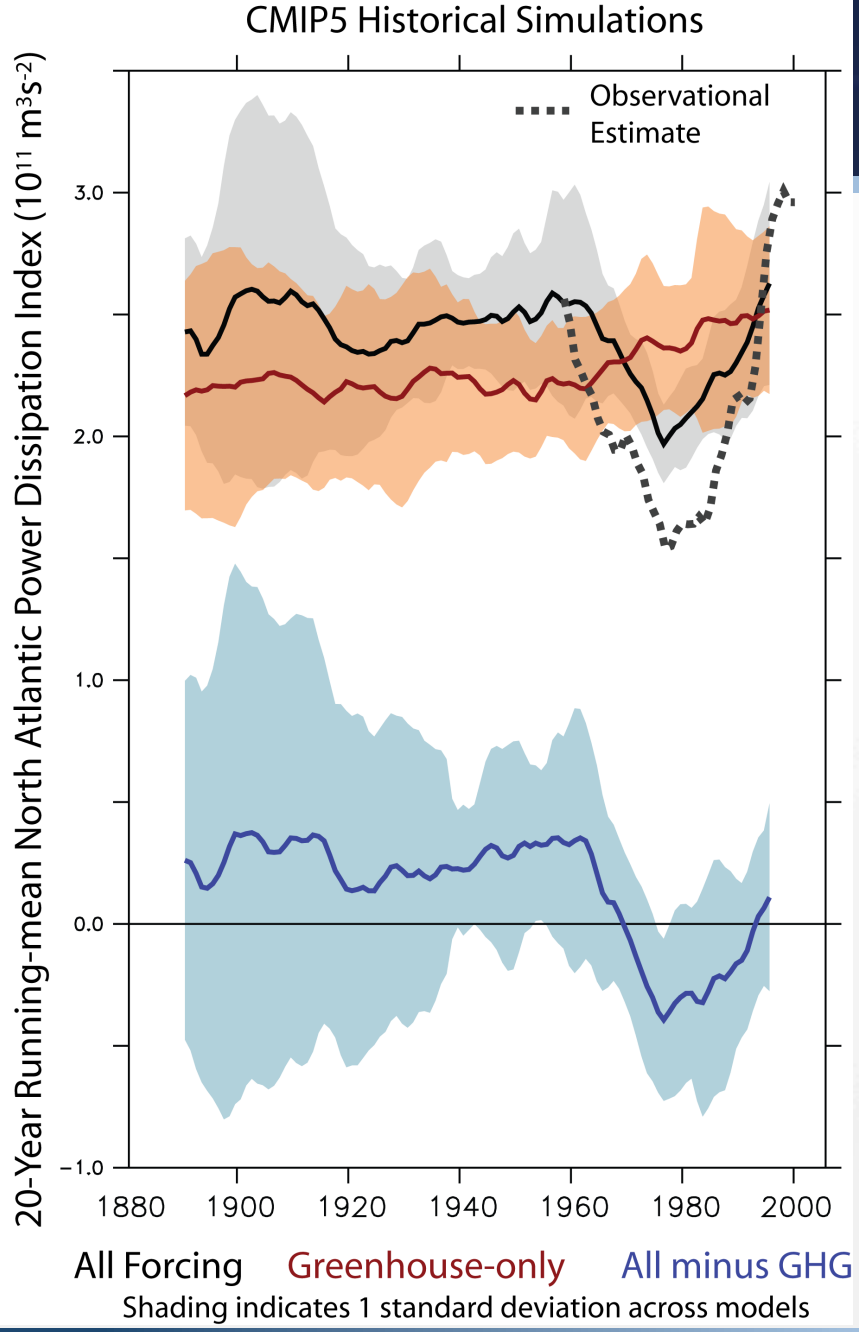
DECADES: Hurricane Attribution and Projection

Historical aerosol forcing may have masked century-scale greenhouse-induced intensification in Atlantic

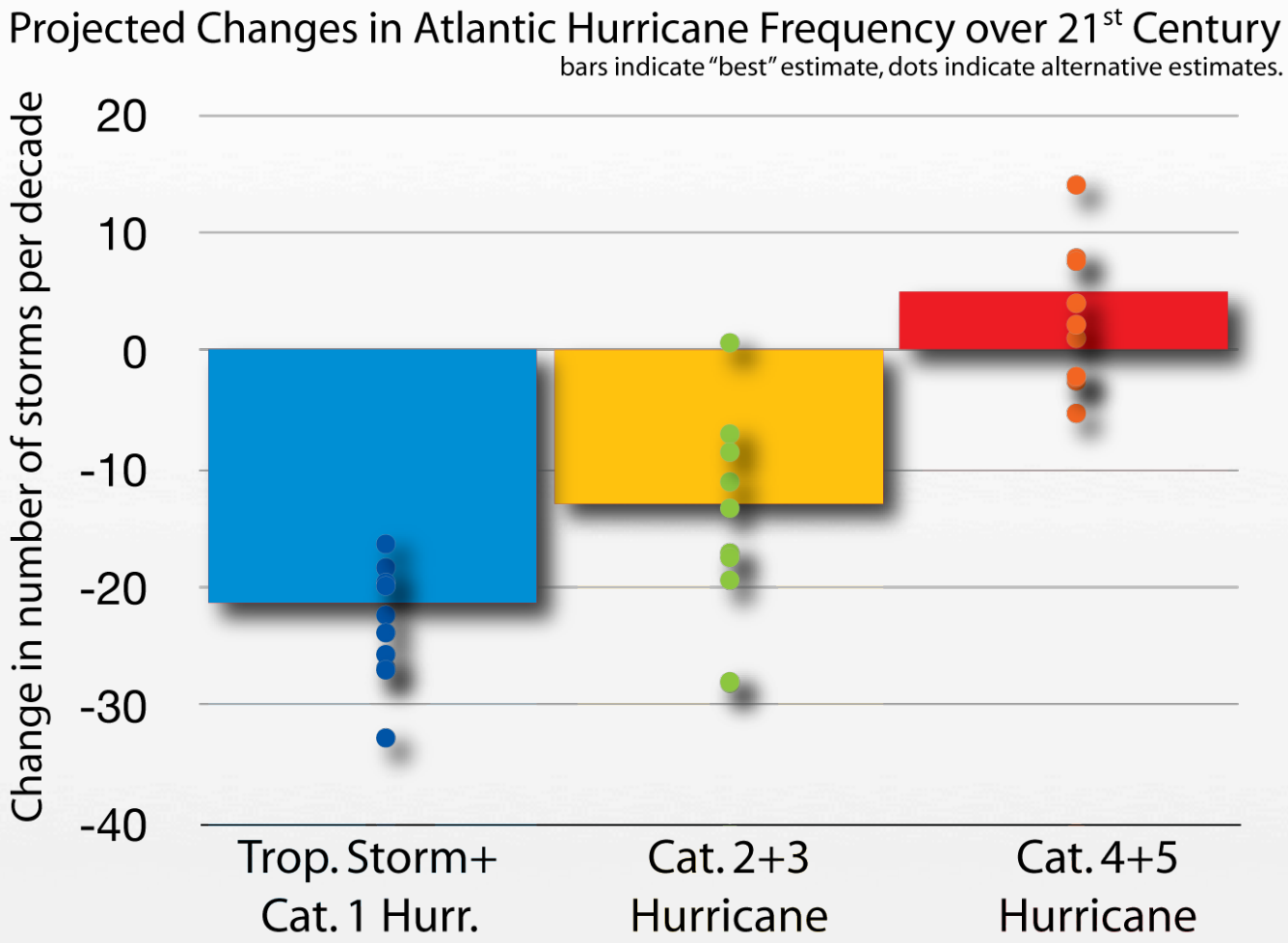
Power Dissipation Index

$$PDI = \sum_{storms} U_{\max}^3$$

Villarini and Vecchi (2013, J. Climate)



North Atlantic frequency decrease & intensity increase, so strongest storms may become more frequent



Adapted from Knutson et al (2008, Nature Geosci.), Bender et al (2010 Science), Knutson et al. (2013, J. Climate)

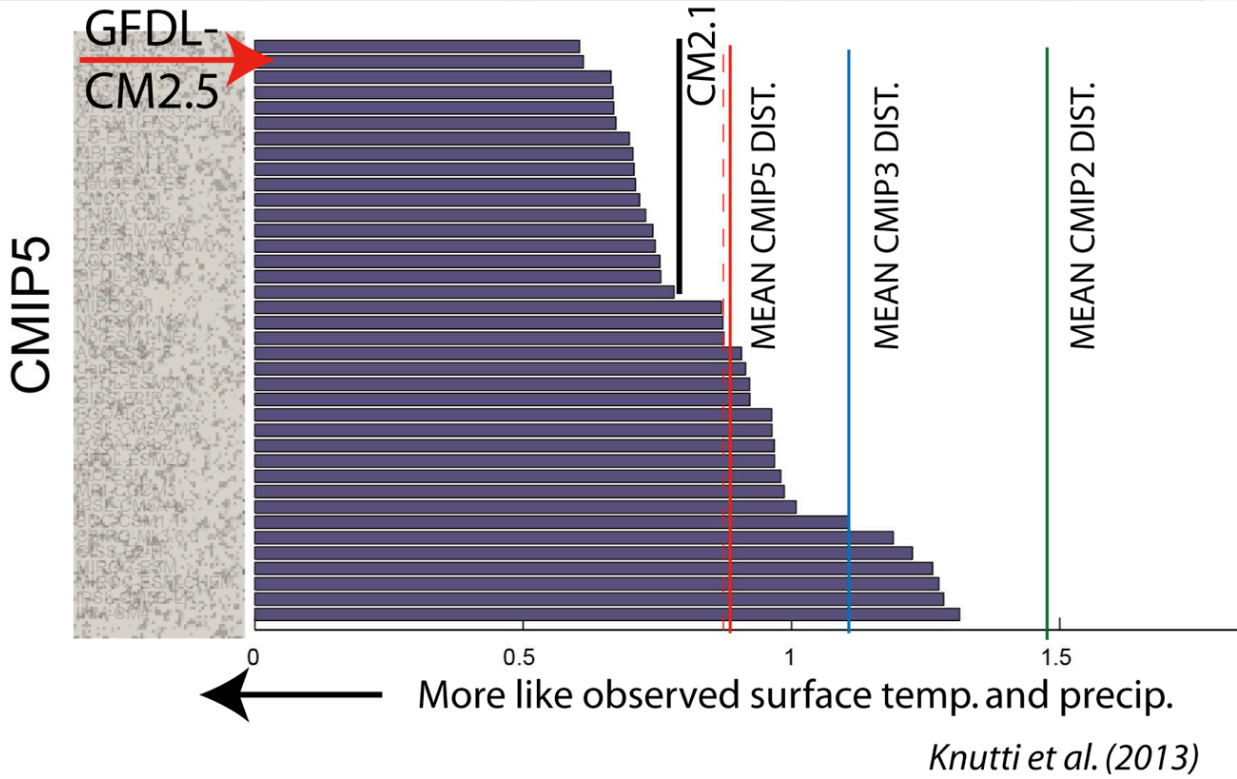
Towards Seamless Prediction Across Timescales: High-resolution coupled prediction - FLOR

FLOR (Forecast-oriented Low Ocean Resolution version of CM2.5)

Goal is to build seasonal to decadal forecasting system to:

- Yield improved forecasts of large-scale climate
- Enable forecasts of regional climate and extremes

Faster computer (Gaea) allows improved resolution that translates into significantly reduced biases in CM2.5 relative to CM2.1

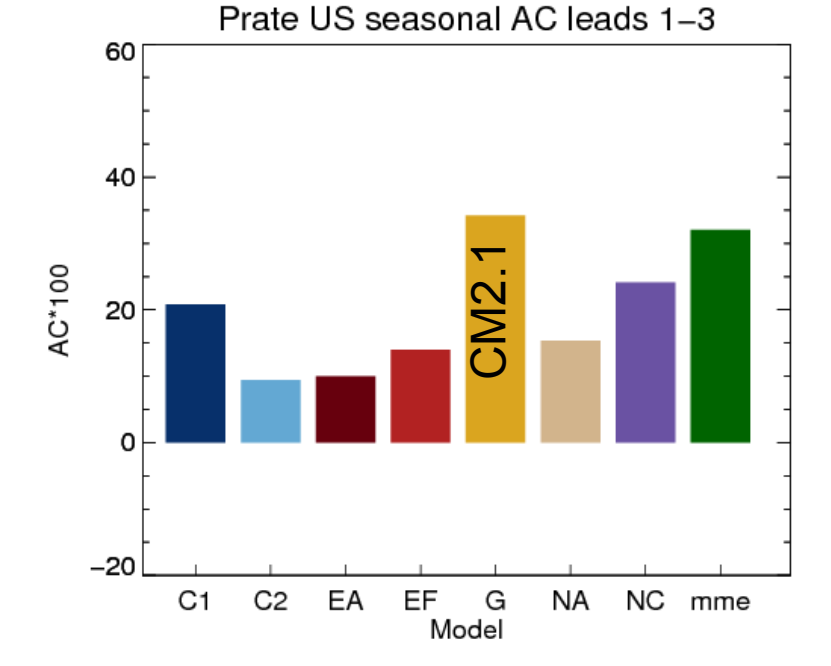


Knutti et al. (2013)

Resolution over land of GFDL SI forecast systems

One goal: to outperform CM2.1

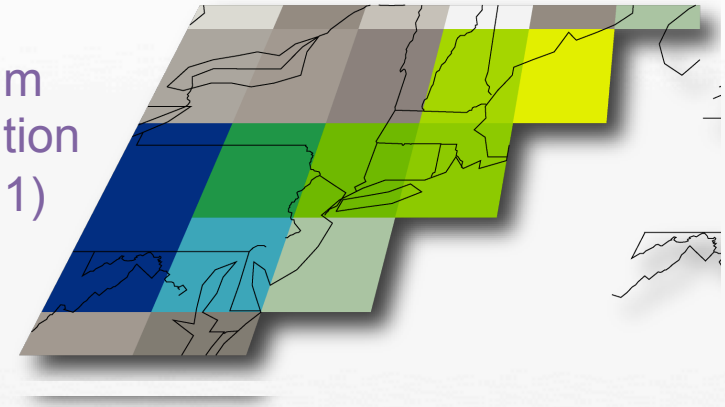
"Real-time" skill of first year of NMME Continental US Precip Forecasts



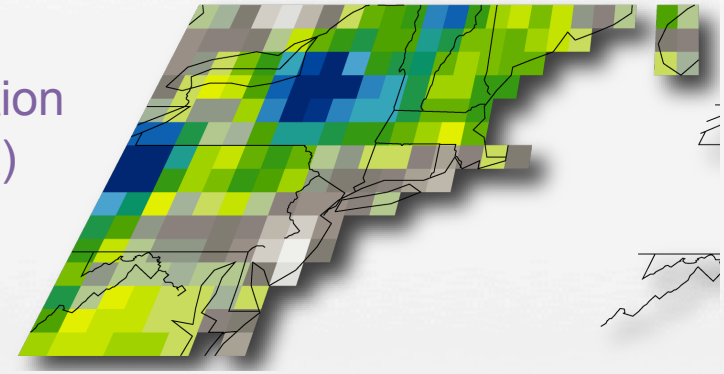
Van den Dool et al. (2013)

High-res enables exploration of regional hydroclimate (including extremes)

Medium resolution (CM2.1)



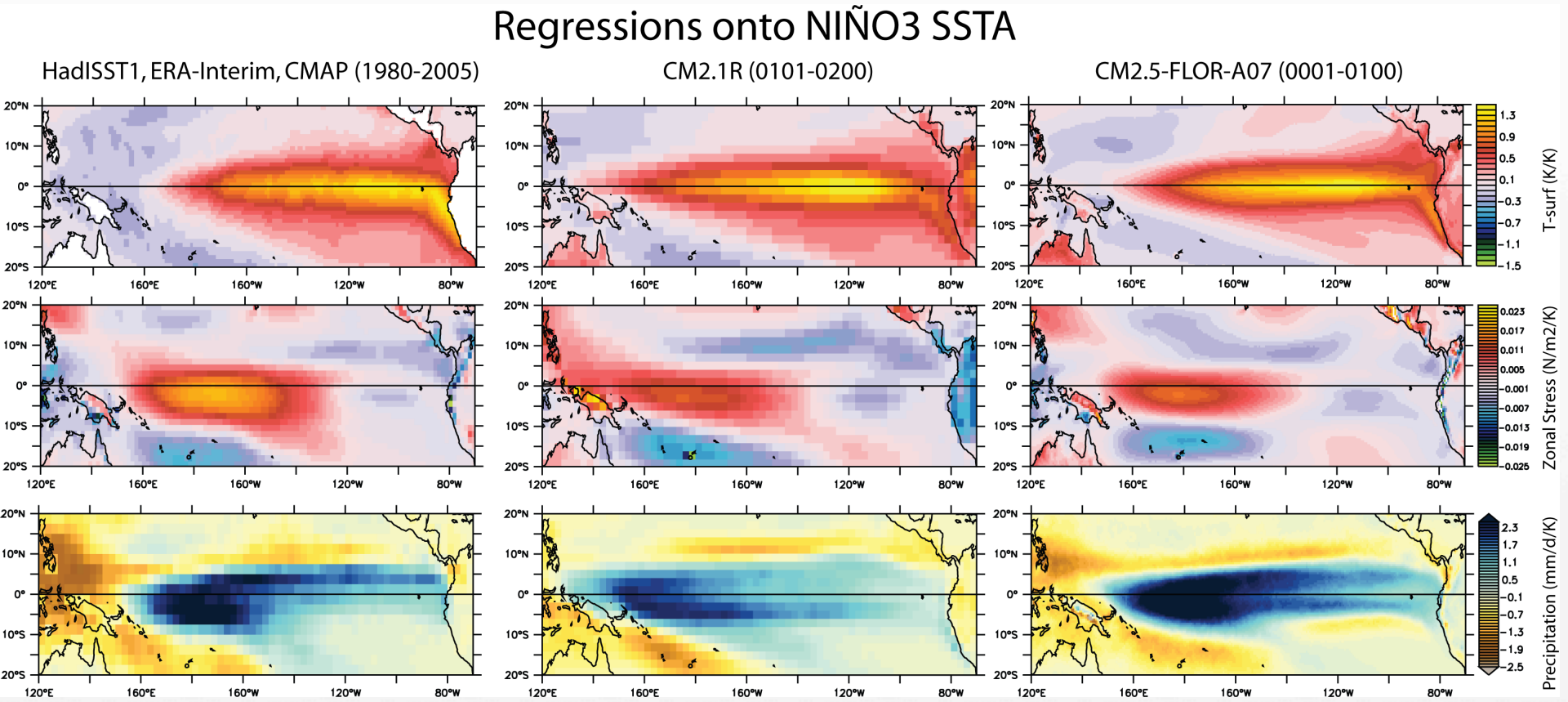
High resolution (FLOR)



Precipitation in Northeast USA

Adapted from Delworth et al. (2012, J. Clim.)

Structure of ENSO anomalies improves in FLOR (captures much of CM2.5's improvement)



OBS

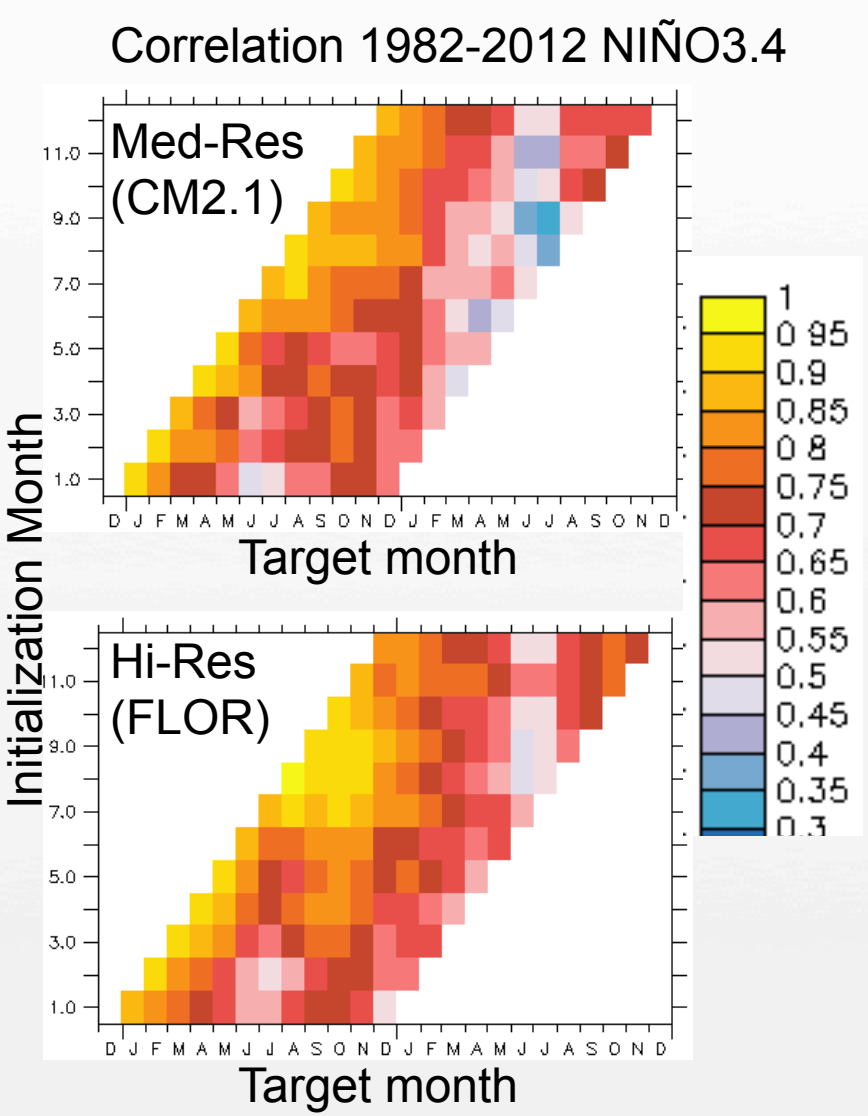
Med. Resolution

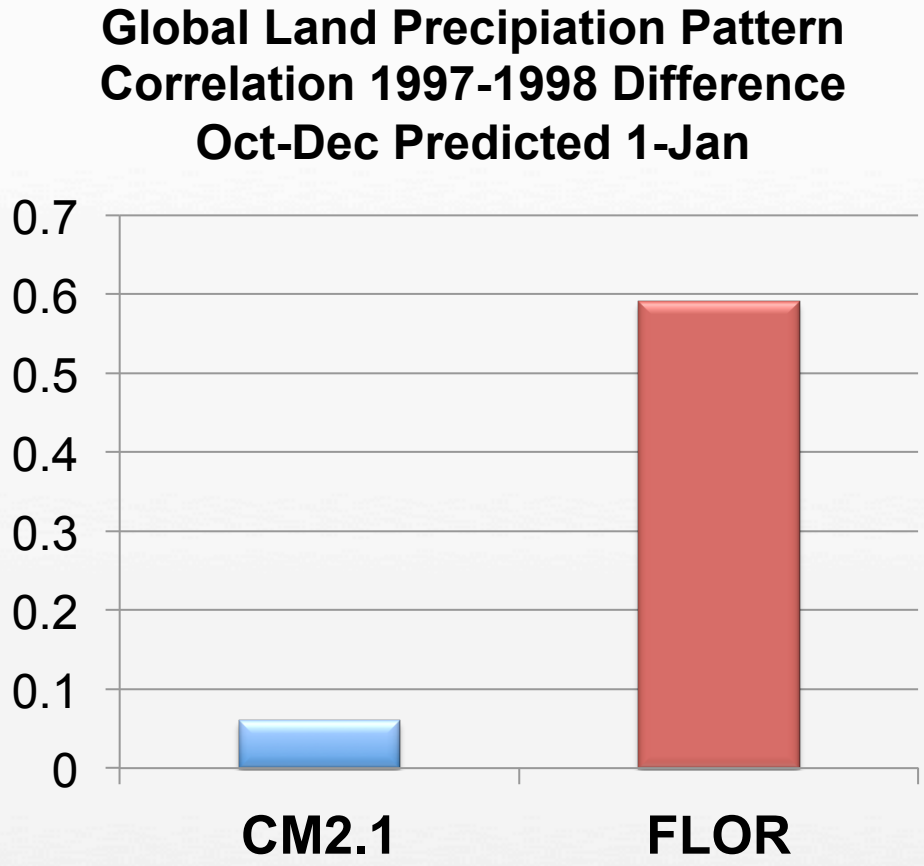
CM2.1

New high-res model

FLOR

Preliminary FLOR forecast results: Improved skill relative CM2.1
(both using CM2.1 I.C.s – not our "best shot")

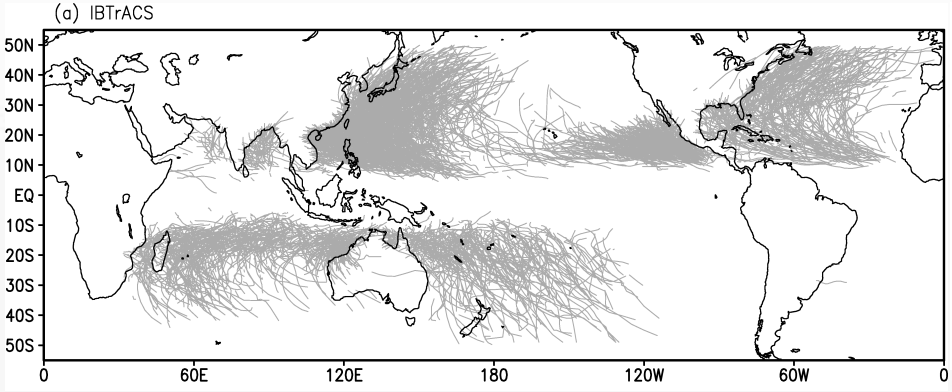




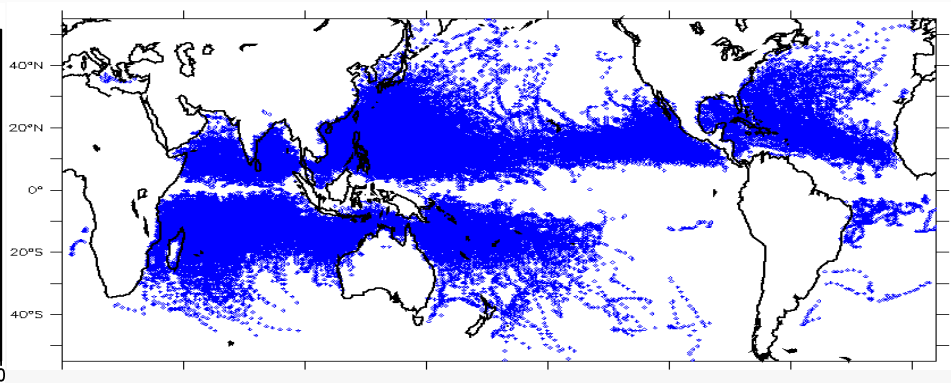
Increase in skill for global and regional surface temperature and precipitation over land (Jia et al. 2013, in prep.)

Prediction of TCs in high-resolution global coupled model (FLOR)

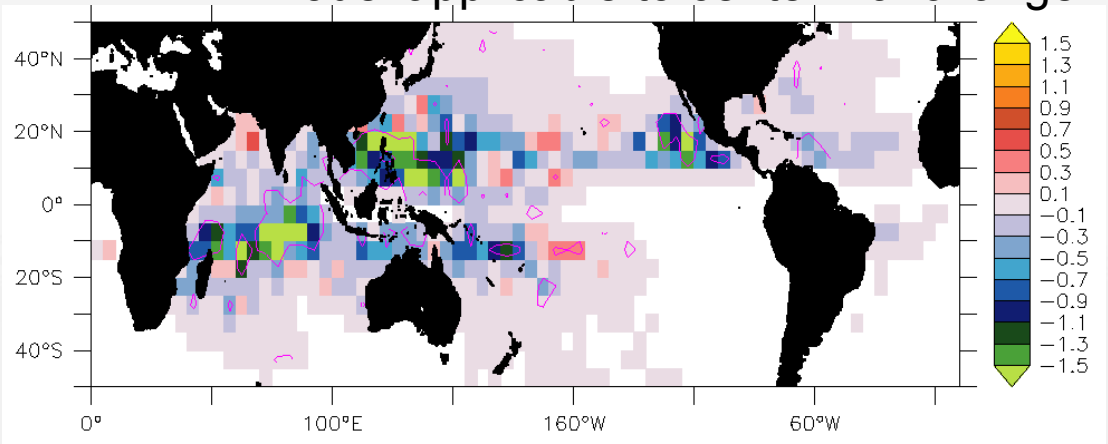
Observed Tracks



Coupled Model Tracks (actual seasonal forecasts)



Model applicable to centennial change



More storms

Fewer storms

CM2.5 Tropical storm density response to CO_2 doubling

(Kim et al. 2013)